



DANGEROUS GOODS PANEL (DGP) MEETING OF THE WORKING GROUP OF THE WHOLE

Abu Dhabi, United Arab Emirates, 7 to 11 November 2010

- Agenda Item 5: Resolution, where possible, of the non-recurrent work items identified by the Air Navigation Commission or the panel**
5.2: Review of provisions for dangerous goods relating to batteries

SECONDARY LITHIUM ION BATTERIES

(Presented by H. Brockhaus)

SUMMARY

Existing dangerous goods transport regulations are designed for various types of lithium portable batteries both in terms of rules for prototypes and samples as well as for series production and tested lithium batteries. Latest modifications enable transport of large prototype batteries.

Beginning proliferation of resulting products (e.g. Hybrid vehicles) generates the need of modifications of the rules to guarantee appropriate and safe logistics of tested large format batteries of a weight greater than 35 kg gross mass. In particular the below listed aspects are worth to be reviewed:

- Full supply chain with multiple countries/authorities;
- Changes of Packing Instruction 965; and
- Special Provision A99 primarily regarding the weight limitations for Lithium batteries.

1. INTRODUCTION

1.1 Societal goals and political guidelines for CO₂ reduction can only be met with the help of advanced technical solutions. Within this context, larger format rechargeable lithium batteries can be used for storage in e.g. energy production from renewable sources such as solar, wind and hydropower, in particular in decentralized installations.

1.2 An additional focus in CO₂ reduction is to decrease consumption of fossil fuels in the automotive sector through the use of large rechargeable lithium batteries in hybrid and electric vehicles.

1.3 International proliferation of this new battery technology is directly linked with the ability for seamless transportation. In consequence revision of the dangerous goods transportation regulations for large rechargeable lithium batteries is highly required. Existing dangerous goods transport regulations were mainly designed for portable lithium batteries for prototypes and samples as well as for series production. Large prototype batteries can be transported under special provisions. A regulation for sustainable, appropriate and safe transport has to be achieved to build up adequate logistic chains.

2. SAFETY LEVEL OF LARGE RECHARGEABLE LITHIUM BATTERIES

2.1 Lithium batteries have been widely used for more than 15 years. They are used in products requiring reliable electrical supply. Portable electronic devices are hard to imagine without this battery technology.

2.2 Apart from some exceptions, the Li-Ion system has never been used in large batteries. Technical innovation in the basic chemistry cell design and the ancillary systems within a battery assembly, prepared the way for the deployment of large batteries in automotive and stationary applications. This also enables the development of high performance hybrid, electrical and fuel cell vehicles. In practice all automotive manufacturers develop a wide variety of hybrid and pure electric vehicles. First vehicles are introduced into the market successfully. Volume manufacturing and worldwide market introduction of lithium batteries in line with hybrid and electric vehicles have been started. Almost all batteries of these cars have a gross mass greater than 35 kg.

2.3 To meet the requirements in automotive applications, lithium cells and batteries are subject to comprehensive and extensive tests. Cells and battery modules are built into complete battery systems or assemblies. Beside the electrochemically active components (cells), the following ancillary systems are contained in battery assemblies: Thermal management including air or liquid coolant system, electrical management system to monitor and control the conditions of each cell, module or battery during charge, discharge and transportation. Such systems are housed in a robust secondary casing. A high built effort is the prerequisite to achieve the required performance data, durability, safety, reliability and minimum a 10 year life cycle.

2.4 Production level large Li-Ion batteries are subject to extensive tests as described in subparagraph 38.3 of the UN Manual of Tests and Criteria. It is assumed that cells and batteries, which have successfully passed such tests, are safe for transportation.

3. PROPOSALS FOR NECESSARY MEASURES

3.1 The following items shall be considered for any new or when amending existing regulations:

3.1.1 A provision or modification of existing rules which consider the logistics of tested large lithium batteries comprising a weight higher than 35 kg coming from series production. This particular may include:

- a) It must be fundamentally assumed that a wide variety of qualified modules and batteries will be manufactured from single certified cells produced and continuously tested according to established quality standards;
- b) Consideration of quality standards incorporated in follow up tests and current production lot controls.
- c) Electronic battery management and ancillary devices ensure safe operation when in normal use. Those also provide a positive impact on transportation safety.
- d) Consideration of the standard, robust secondary housing and the resulting positive impact on transportation safety (can even replace the packaging and allow palletized transport).
- e) Non compliance with existing transport regulations for Li-Ion batteries often are not intended but occur due to missing transparency of test status and applicable approvals. It should therefore be evaluated, to what extent a visible quality seal would result in increased awareness. A modification of the actual approval practice may also be discussed.

3.2 Germany intends to file a working paper covering those issues during the next meeting DGP-WG/11. Therefore we appreciate comments and input from the panel members. Any feedback will be considered and used to develop a proposal that shall meet wide acceptance and support.

4. CHANGE OF RULES FOR 35KG LIMITATION (A99)

4.1 In anticipation of the expected discussion, the following proposal shall be offered for initial review:


- Lithium-Ion Batteries for automotive propulsion purpose are nearly always heavier than 35kg;
- Such batteries are generally tested according to subchapter 38.3 of the UN Manual of Tests and Criteria;
- Additionally all batteries run through all tests required for the car and passenger safety according to the regulations in force, especially crash and crush requirements;
- To increase the safety of the transport of batteries exceeding 35 kg G by CAO it is highly recommended to only allow one large battery per package;

- In case that all of the above-mentioned safety aspects are completely fulfilled, the transport of lithium batteries exceeding 35 kg G by CAO should be possible without any kind of approval (a transport of lithium batteries exceeding 35 kg G by CAO without any kind of approval would then make sense.); and
- This does not affect current limitation of package weight for small batteries.

5. CONCLUSION

5.1 The DGP-WG is invited to discuss this issue with a view to identifying the adequacy of the further actions which may be needed. For additional information, please consult the PowerPoint presentation in the Appendix to this IP for discussion with the experts in your countries.

APPENDIX


 Luftfahrt-Bundesamt

Large Lithium-Ion-Batteries

Technology and Application



Hermann Brockhaus
LBA, Germany



10/13/2018 Page 0

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Large Lithium-Ion Batteries - Highlights

- Batteries greater 12kg are defined as large batteries
- Are already available in mild hybrid vehicles
- are planned for all upcoming hybrid and BEV vehicle programs
- are classified as Dangerous Goods UN3480
- Series production must be 38.3 tested
- Today's regulations are tailored for consumer electronic batteries/cells
- When not 38.3 tested no transport in vehicle or equipment





10/13/2018 Page 1

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Large Li-Ion Batteries in Vehicles

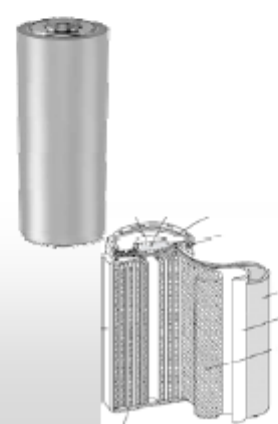
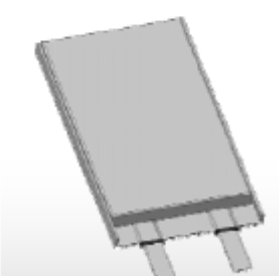
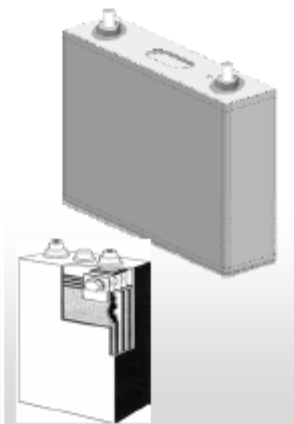
- hybrid vehicles of different levels (HEV)
- plug-in hybrid vehicles (PHFV)
- fuel cell vehicles (FCV)
- battery electric vehicles (BEV)



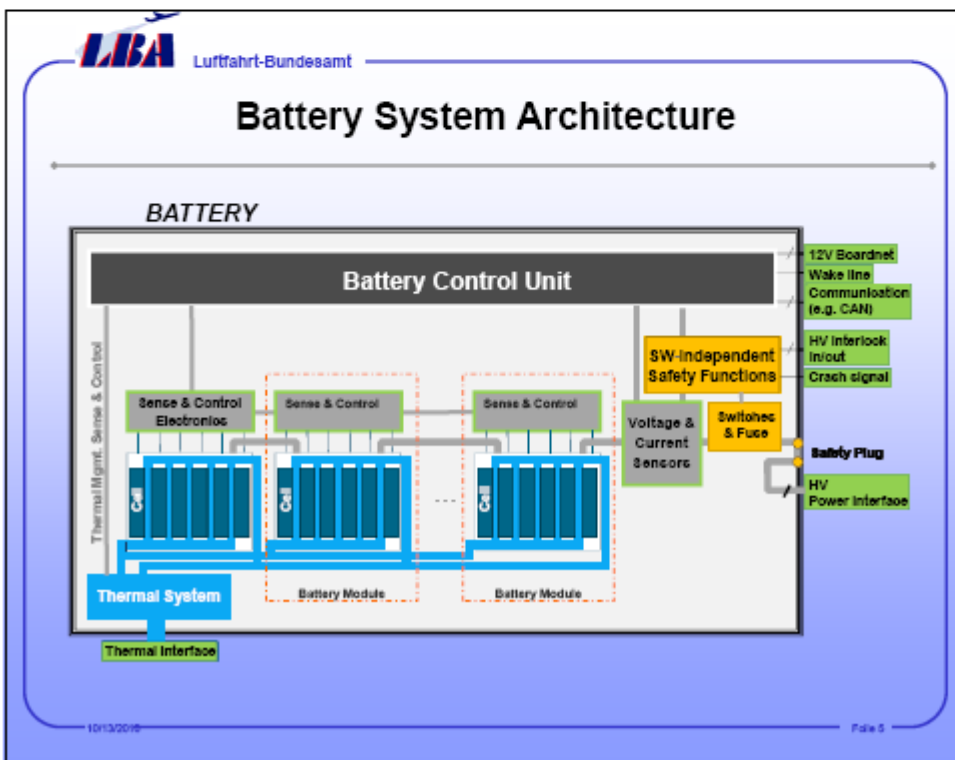
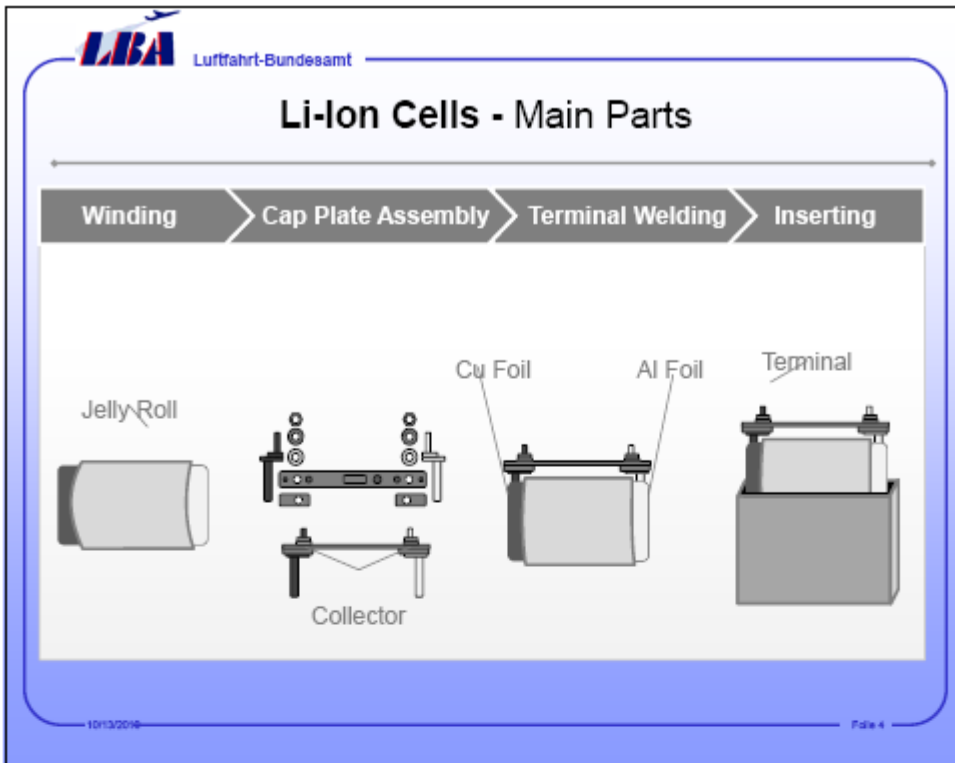
10/13/2016 Seite 2

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General Design of a Battery Cell

Cylindrical Cell (Hardcase)	Pouch Cell (Softpack)	Prismatic Cell (Hardcase)
		

10/13/2016 Seite 3



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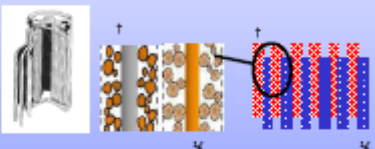
Layout of cells high power vs high energy

High Power Cells
„100m Sprinter“

HYBRID

High specific Power
Low specific Energy

Small Cells, thin, porous electrodes



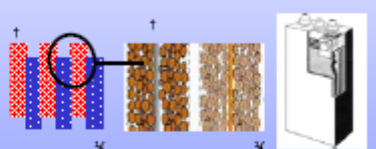
Capacity:	5Ah
Mass/Volume:	0,25kg, 125cm ³
Spec. Energy:	80Wh/kg
Spec. Performance:	>2000W/kg
Cost:	???

High Energy Cells
„Marathon runner“

Plug in Hybrid, Electric Vehicle

High specific Energy
Low specific Power

Large Cells, thick, dense electrodes



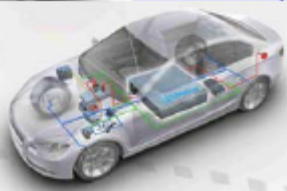


Capacity:	50Ah
Mass/Volume:	1,2kg, 750cm ³
Spec. Energy:	150Wh/kg
Spec. Performance:	~700W/kg
Cost:	???

10/13/2016 Folie 6

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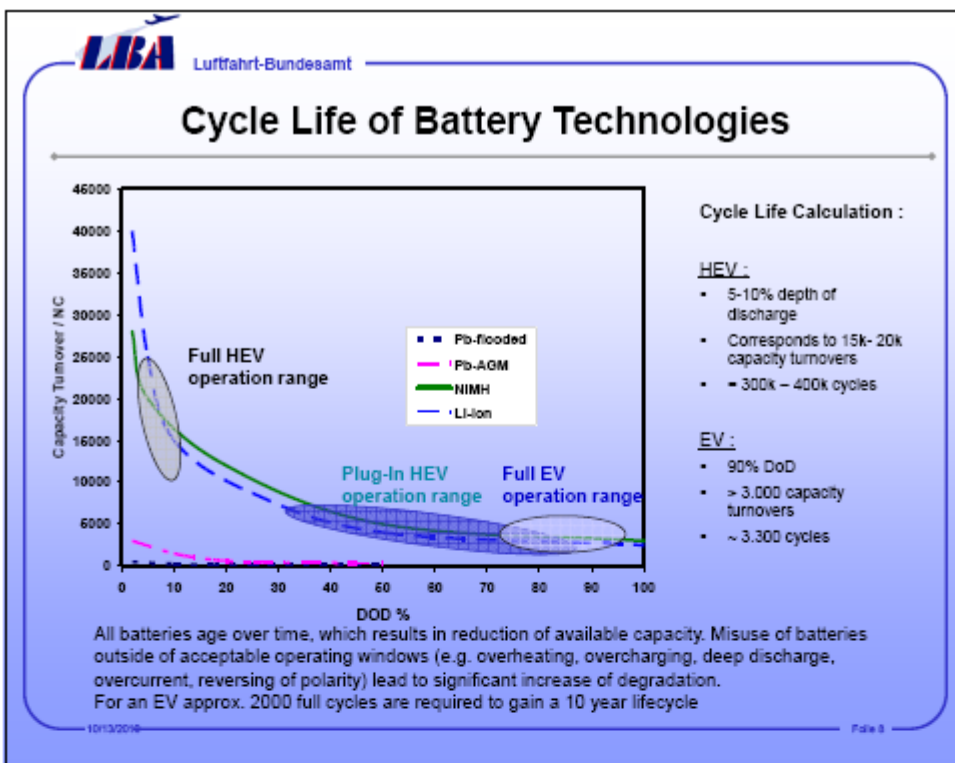
Battery in Vehicle

Battery is hidden in vehicle structure for the following reasons:

- >Vehicle dynamics
- >Crash requirements
- >Vehicle package

10/13/2016 Folie 7



Li-Ion Battery Suppliers for Automotive Application

Supplybase is characterized by joint ventures between battery (cell) manufacturers and automotive tier 1 suppliers or OEMs

Cells and Systems Li-Ion Automotive	Automotive Cells			Automotive System Developer
	HEV	PHEV	EV	
PEVE (Joint Venture Toyota-Panasonic)	✓	✓		Toyota
Matsushita Battery (Panasonic)	?			none
Sanyo	✓	(✓)		
JCS	✓	✓	✓	JCS
SB-LiMotive (Joint Venture Samsung - Bosch)	✓	(✓)		Bosch
Hitachi / Shin-Kobe	✓	?	✓	
AESC (Joint Venture NEC-Nissan)	?	✓	✓	Nissan
LEJ (Joint Venture Mitsubishi - GS Yuasa)			✓	Mitsubishi
LG Chem	✓	✓		CPI
A123Systems	✓	✓		Magna, Continental
SK Corporation	✓	✓	?	?
Toshiba	✓			tbd
Conti / Enax	✓	✓		Continental
Kokam, EnerDel, AitarNano, Gala, Li-Tec, ...				none
China, Taiwan: BYD, HYB, Lishen, Thundersky, Phyllon, E-ONE Moli, Sunyen, ... and others				???

Status 2009

10/13/2010 Page 4

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Automotive Li-Ion Batteries Key Success Factors


The diagram shows a yellow box labeled 'Battery' connected to a white box labeled '3~' (representing 3-phase AC) and a white circle labeled 'M' (representing a Motor). The connection is shown with lines and an equals sign (=) between the battery and the AC source.

Factor	Requirements
Safety	No thermal incidents in field
Performance	> 5000 W/kg (HEV) > 200 Wh/kg (EV)
Quality	Small manufacturing tolerances
Lifetime	> 10 years > 250 000 km
Cost	< 30 \$/kW(HEV) < 300 \$/kWh (EV)

Challenges

- Requirements have to be fulfilled all together
- Automotive requirements much more severe than in consumer business
- Implementation of whole value chain including recycling
- Promotion of standardization
- Build up of infrastructure

10/13/2016 Folie 10


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Large Lithium-Ion-Batteries

Transportation Attachment

Herrmann Brockhaus
LBA, Germany

10/13/2016 Folie 11


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Transportation of a Li-Ion Battery

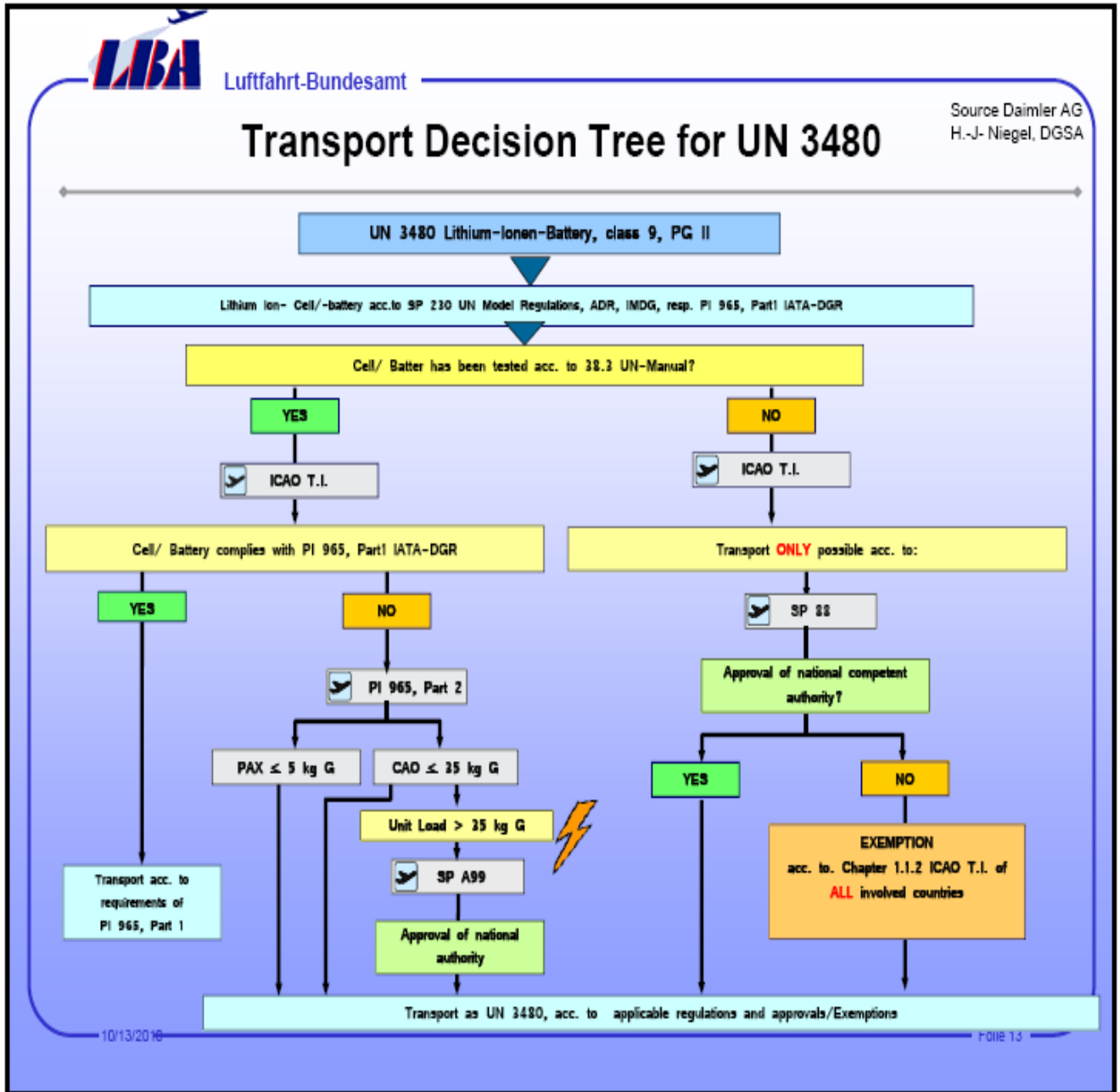
For the air shipment of a battery in 2011 the following steps are required:

Battery (example): fully 38.3 tested; 150kg total weight, capacity 15kWh

- Shipment as UN3480, class 9, gross mass greater 35kg
- Strong outer packaging
- Approval „state of origin“ in line with definition DGP/22-WP/100 report
 - National competent authority of sender state
 - National competent authority of airline operator state
- Copy of approval must accompany the shipment



10/13/2016 Folie 12





Need for Amendment of Regulations

Alternatives:

- 1) **Collaborate with ICAO WGH to achieve contemporary and safe transportation regulations**
- 2) **„Do nothing“, let others pursue amendment of regulations – consequences are:**
 - **no attempt to adapt regulations to industry needs based on safety level**
 - **Existing regulations persist through 2013 and beyond, leading to following scenario:**
 - No emergency supply of batteries for production
 - Delay of service battery supply to customers
 - Not plannable airfreight for marketing events, fairs, exhibitions
 - No opportunity for short term reaction on defects, failures etc.
 - Program timings at risk for any unforeseen incident where a quick transport is necessary.
 - **No change of regulations for vehicles with Li-Ion Battery fitted**

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Large Lithium-Ion-Batteries







CHANGE OF RULES FOR 35kg LIMITATION (A99) Attachment

Herrmann Brockhaus
LBA, Germany

10/13/2016 Seite 15

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CHANGE OF RULES FOR 35kg LIMITATION (A99)

Small Li-Ion Batteries <35kg (resp. 5kg on PAX)	Any Li-Ion batteries	Li-Ion Batteries >35kg
MANY batteries in one pack <35kg (5kg)	MANY batteries in one pack >35kg	ONE per Pack ONLY when weight >35kg
No change of Regulation (transport accepted for CAO or PAX)	No Change of Regulation (competent authority approval required)	NEW Proposal
		
		

MANY = more than ONE

10/13/2016 Seite 15